School disruption and pupil academic outcomes – evidence from the 2001 foot and mouth disease epidemic in England

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The Covid-19 crisis has led to disruption to schooling across the world. Though it is recognized that pupils are suffering immediate learning loss, there exists a lack of understanding as to how this disruption might affect longer-term educational outcomes. This study considers this issue by examining the effect of school disruption in England due to restrictions put in place to manage the Foot and Mouth Disease epidemic in cattle in 2001. Using a difference in difference approach, I analyze whether primary schools that had been significantly disrupted by the epidemic experienced lower performance in standardized tests in English, maths and science for 11 year olds in the year of the outbreak and in subsequent years. I find that primary schools that had been significantly disrupted by the measures to contain the epidemic exhibited achievement falls in the year immediately after the outbreak, driven by sizeable falls in maths performance. The negative effects weaken in subsequent years suggesting that the effects of school disruption may fade out as cohorts progress through schooling.

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1 Introduction

1.1 Background and related literature

In response to the Covid-19 pandemic, schools have been fully or partially closed in an effort to control the spread of the virus. This pause in education provision and the reliance on schooling at home has led to concerns about the long-term effect of foregone learning and the potential for these effects to exacerbate existing educational inequalities. Evidence from the UK and USA suggests that many pupils are not engaging in their schools' efforts to maintain education provision (Lucas et al, 2020; Cullinane and Montacute, 2020) and that there exists a substantial difference in home learning between the highest and lowest income households (Chetty, 2020; Andrew et al, 2020; Anders et al, 2020). However, current studies of the impact of Covid-19 on learning can only measure the short-term impacts of school disruption on learning *inputs*; the long-term impact on pupil attainment is a matter of conjecture. Burgess and Sievertsen (2020) provide an estimate of the learning loss due to missing 12 weeks of schooling of up 10% of an S.D. unit, based on studies that have estimated the effect of varying instruction time in schools (Carlsson et al, 2015; Lavy, 2015).

There are a couple of historical parallels with the current situation of widespread school disruption due to pandemics. Meyers and Thomasson (2017) find that likely school disruption due to measures to control the 1916 polio pandemic in the USA resulted in pupils obtaining less years of education compared to individuals who had left school in the years just prior to the pandemic. Goulas and Megalokonomou (2020) study the impact of relaxing school attendance requirements in Greece in response to the H1N1 swine flu epidemic. They find that when school attendance rules are relaxed it is high attaining pupils that tend to attend school less and their academic performance suffers.

This paper aims to provide further evidence to aid the assessment of long-term effects of the disruption to schooling due to Covid-19. It does so by estimating the effect of school disruption related to school closures, pupil movement restrictions and the psychological distress of pupils that was caused by measures to contain an epidemic in cattle, the 2001 foot and mouth disease (FMD) outbreak in the UK. The modelling estimates the effect of the outbreak on schools' test score

performance on standardized tests for 11 year olds in maths, English and science in the year of, and those following, the crisis. Examining these test scores across cohorts allows an assessment of whether any effects school disruption are sustained over time or whether they are mostly just apparent in the immediate aftermath of a crisis.

1.2 The FMD Outbreak

FMD is a highly infectious viral disease that causes blistering on the hooves and the mouth of cattle and other livestock, affecting movement and feeding; it is potentially fatal to young cows. There is however no significant threat to human health. The FMD epidemic in the UK lasted from February 2001 until the last case was declared in September 2001, although measures to contain the disease lasted in some places into 2002. A number of measures were implemented to reduce the transmission of the virus, including widespread culling of livestock, movement restrictions on livestock and the closure of countryside rights of way, and, of relevance to this study, the closure of schools and other public institutions. Even when schools were open, pupils and staff from some locations were advised or simply chose not to travel for fear of spreading the virus[2]; in some cases, pupils were off school for months and schools resorted to delivering education via post.

Along with the effect on school pupils from missing school, through closure or otherwise, the FMD outbreak also had serious psychological effects on farming communities that lost livestock due to the mass culling and burning of the animal carcasses (Mort et al, 2001). The widespread closure of the countryside and the images from the outbreak also had the effect of deterring tourism from the affected areas, which further compounded the economic effect of the outbreak. Taken together, it is hypothesized that the disruption to school opening and attendance, along with the stressful environment that the outbreak created in the affected communities affected the learning of pupils living in the affected areas.

[2] The official report of the Cumbria FMD task force provides details of the restrictions imposed and the effect on local communities in the UK's worst affected area:
https://www.cumbria.gov.uk/eLibrary/Content/Internet/538/716/37826163827.pdf

2 Data & Method

2.1 Data description

The data used is publically available school performance data covering all mainstream primary schools in England from 1997/1998 – 2005/2006. For this period, pupils took standardized tests ("KS2 tests") in English, maths and science[3] during the May of the school year in which they turn 11 years old. These tests are used for published school performances measures and for setting the baseline for pupil progress over secondary school. During the period in question, the main school performance measure was the percentage of pupils reaching the 'expected level' for each subject and the average of these percentages over the three subjects. These measures are used as the outcome measures in this study. Schools were identified by their local education authority as being 'significantly affected' by FMD[4] in order that this could be reported alongside their school accountability measures published in 2001. Unfortunately data on the exact nature of the disruption does not exist, however school absence data indicates that the number of days that pupils were absent in affected schools was 30% higher in 2001 compared to the years after the outbreak[5]. Given that the outbreak affected just a third of the academic year this suggests that the FMD outbreak had a substantial effect on pupil absence.

The sample is restricted to schools that had a full set of attainment data for this period[6], this leaves 52 FMD affected schools and 11,024 control schools. Descriptive statistics are shown in table 1. These show that FMD affected schools had, on average higher attainment prior to the outbreak and that this was maintained post crisis. In order to control for these and other[7] pre-existing differences, the estimate of the effect of the outbreak is made using a differences in differences design including school fixed effects. In addition, I use leads in an event study analysis to examine whether estimated effects may be driven by pre-existing trends.

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[3] Science tests were discontinued after 2009.
[4] This was decided upon by the Local Education Authority with guidance from central government that schools should be designated as significantly affected by FMD if schools performance is likely to have been affected 'because pupils have been absent for prolonged periods or because they have been affected by the stress and trauma surrounding the disease' DfES (2002).
[5] Authors analysis; school absence data was only collected from 2001 so a before/after comparison cannot be made.
[6] The main reason for schools having incomplete data is that school performance data is suppressed when the number of pupils taking the tests is less than ten, for privacy reasons.
[7] E.g. FMD affected schools are more likely to be located in less densely populated areas.

Table 1. Descriptive statistics

		FMD affected schools		Control Schools	
		Before	After	Before	After
Age 11- proportion reaching expected level					
3-Subject Average					
	Mean	0.793	0.854	0.730	0.804
	SD	0.131	0.090	0.155	0.121
Maths					
	Mean	0.754	0.806	0.683	0.752
	SD	0.159	0.126	0.174	0.146
English					
	Mean	0.779	0.832	0.716	0.781
	SD	0.141	0.109	0.161	0.139
Science					
	Mean	0.847	0.924	0.790	0.880
	SD	0.129	0.073	0.162	0.109
Observations		156	312	33,072	66,144

Note: 'Before' refers to observations prior to 2001; 'After' refers to observations from 2001 onwards.

2.2 Empirical approach

To estimate the effect of the disruption caused by the FMD outbreak on affected cohorts a simple difference in difference model is estimated:

$$y_{st} = \alpha_s + \tau_t + \gamma FMD_{st} + \epsilon_{st} \quad (1)$$

Where y is the percentage of pupils passing the expected level of attainment for English, Mathematics or Science at age 11 and the average over the three subjects, in school *s* for year *t*. α_s are school fixed effects and τ_t are a set of time fixed effects that control for time invariant school characteristics and common cohort shocks respectively; there are no explanatory variables in the model due to data availability. FMD is a dummy variable indicating if a school was identified as being significantly affected by FMD from 2001 onwards; γ is the difference in difference estimate of the FMD school disruption averaged out over all affected cohorts. However as the outbreak occurred at a specific point in time it may be the case that the effect of the outbreak was most apparent for those cohorts that took the tests during or immediately after the crisis. At the same time, while younger cohorts may have been affected by the outbreak, by the time they came to take their age 11 tests, they may have managed to 'catch-up' any lost learning. To test this idea, an event study framework is used:

$$y_{st} = \alpha_s + \tau_t + \sum_{t=-2}^{t=6} \gamma_t (FMD * T)_{st} + \epsilon_{st} \quad (2)$$

Where FMD*T represents the interaction between a dummy variable for a school being identified by its local education authority as being significantly affected by FMD and a set of time dummies, with the year before the outbreak, 2000, as the reference category (i.e. t=0). The set of coefficients γ_t provide estimates of the effect of the FMD disruption for t>0 for each cohort as each cohort passes through the end of primary school tests. For t<0, γ provides a test of the parallel trends assumption. All results are weighted by the number of pupils in each school-cohort[8], and standard

[8] In practice this makes little difference to the results.

errors are clustered at the level of the school. The models are estimated for each outcome: maths, English and science, and the average over the three subjects).

3 Results

The simple difference in difference estimates as per (1) are shown in table 2. A negative effect of the FMD disruption is found over each of the outcomes. For the 3-subject average the estimated effect is a reduction in the proportion of pupils reaching the expected level on 1 percentage point (approx. 10% of a SD), with the largest estimated effect being on maths performance and the smallest on science. These estimates are however not statistically significant.

Table 2. Difference in difference estimates

Outcome	
3-Subject Average	-0.01
	(0.01)
Maths	-0.015
	(0.011)
English	-0.01
	(0.011)
Science	-0.004
	(0.013)
Observations	99331

Notes: The table reports estimates of γ for each of the outcome measures. Standard errors clustered by school reported in parentheses, ***p<0.01, **p<0.05, *p<0.1. Regressions are weighted by the number of pupils in each school-cohort.

The estimates from the event study estimation are shown in table 3, with corresponding graphical results in figures 1-4. Over the three subjects, average there is a sharp and statistically significant fall in results for FMD affected schools in the year after the crisis, 2002, with results recovering somewhat afterwards. The estimates and figure 1 suggest that after the initial shock in 2002, the performance of subsequent cohorts was 1 percentage point lower than it would have been, though these estimated effects are not statistically significant. The estimates for the treatment leads (1998 and 1999) are very close to zero indicating that pre-existing trends are not driving the results and that the parallel trends assumption is reasonable.

Results in all subjects exhibit a fall in 2002; however, the main effect appears to be on maths, where the effect of the FMD outbreak is estimated to be a reduction of 5.4 percentage points (34% of an SD) in 2002 with negative but declining effects estimated for subsequent cohorts. Across all outcome measures, it is clear that the FMD outbreak did not appear to have any effect on test performance in 2001, i.e. when test were taken during the outbreak.

Table 3. Difference in difference estimates by individual cohort (event study)

	3-Subject Average	Maths	English	Science
1998*FMD	-0.003	-0.008	-0.02	0.019
(pre)	-0.017	-0.022	-0.02	-0.02
1999*FMD	-0.001	-0.027	0.012	0.011
(pre)	-0.014	-0.017	-0.016	-0.02
2001*FMD	-0.002	-0.009	-0.007	0.009
(post)	-0.013	-0.018	-0.017	-0.01
2002*FMD	-0.027 **	-0.054 ***	-0.018	-0.01
(post)	-0.012	-0.015	-0.016	-0.01
2003*FMD	-0.01	-0.032 **	-0.017	0.018
(post)	-0.012	-0.016	-0.018	-0.02
2004*FMD	-0.008	-0.026	-0.01	0.011
(post)	-0.014	-0.016	-0.021	-0.02
2005*FMD	-0.009	-0.025	-0.008	0.007
(post)	-0.015	-0.017	-0.018	-0.02
2006*FMD	-0.01	-0.011	-0.015	-0
(post)	-0.016	-0.017	-0.02	-0.02
Observations	99,331	99,331	99,331	99,331

Notes: The table reports estimates of γ_t from (2) for each of the outcome measures. Standard errors clustered by school reported in parentheses, ***p<0.01, **p<0.05, *p<0.1. Regressions are weighted by the number of pupils in each school-cohort.

Figure 1. Average of 3 subjects (maths, English, science): event study estimates

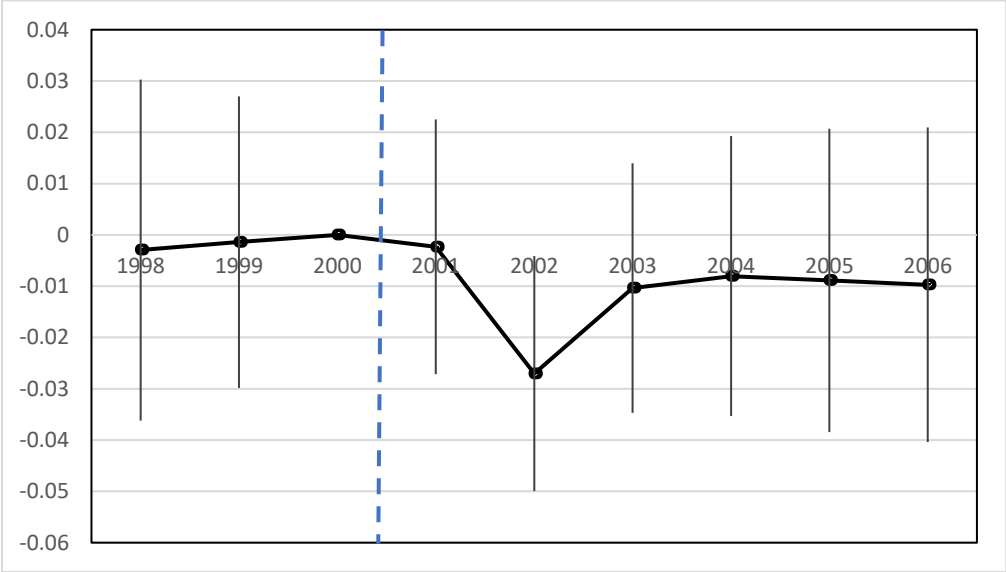


Figure 2. Maths: event study estimates

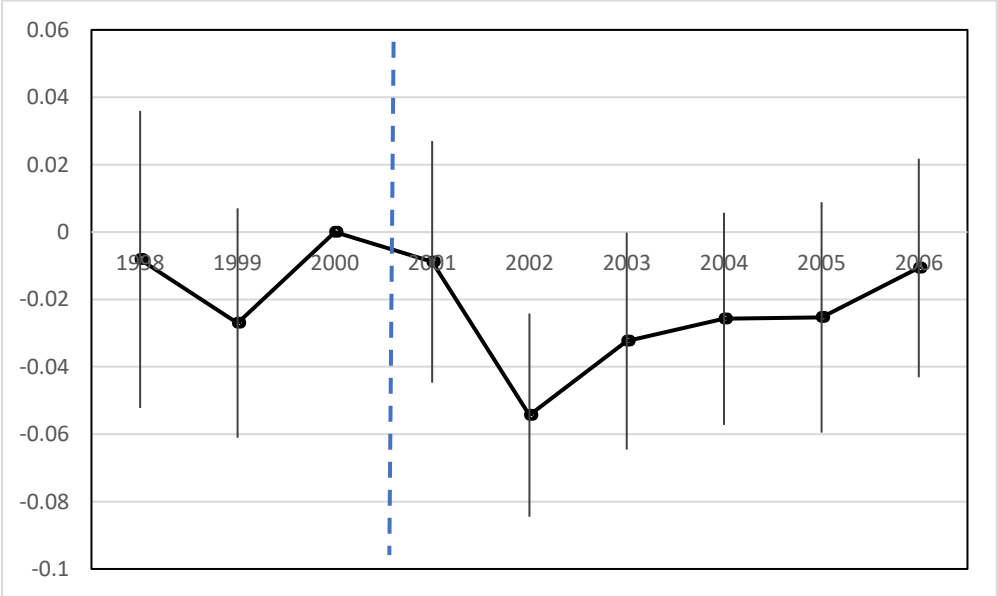


Figure 3. English: event study estimates

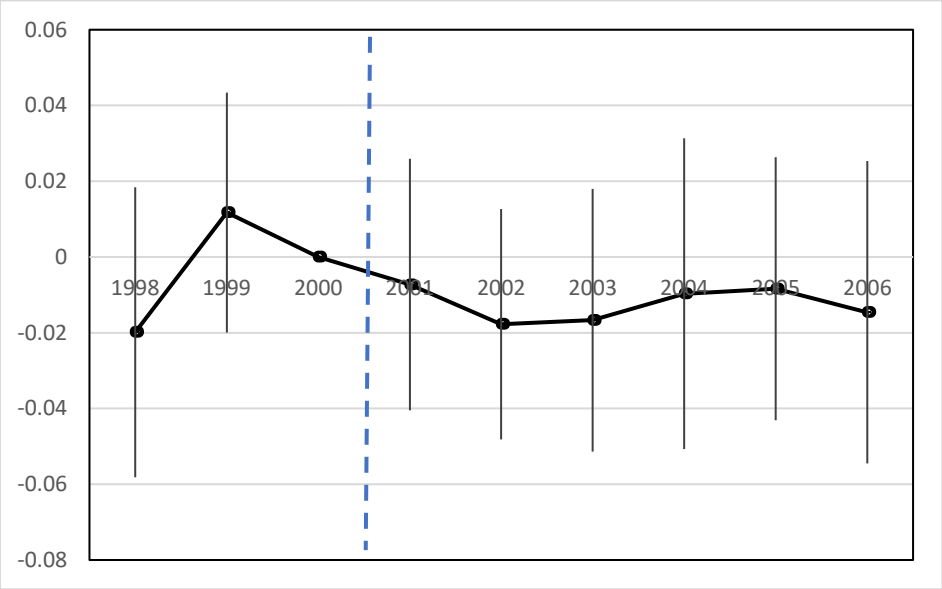
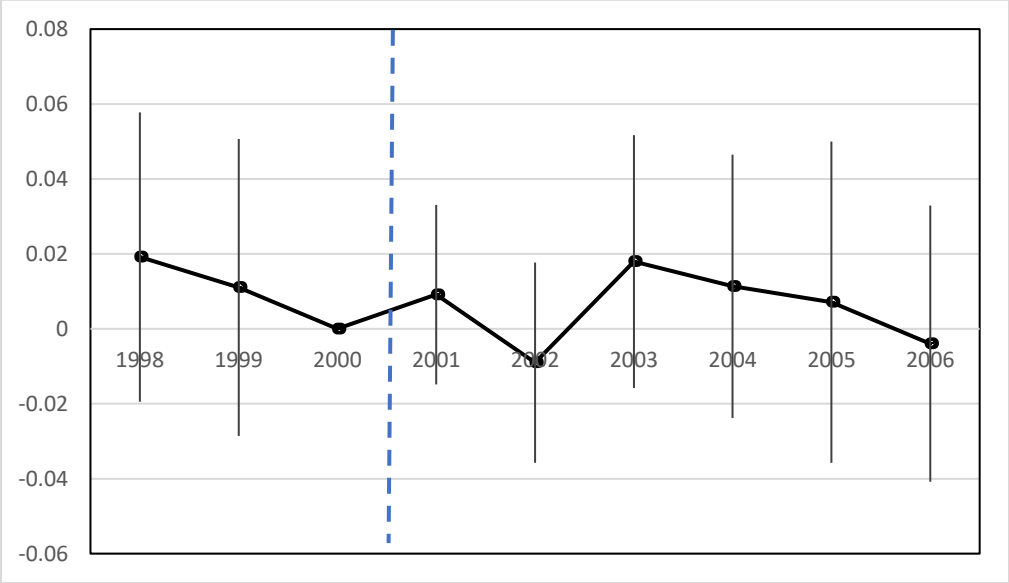


Figure 4. Science: event study estimates



4 Conclusion

4.1 Summary of results

The analysis presented here provides evidence that disruption to schools due to the FMD outbreak affected the test performance of affected schools. The main result is that affected schools experienced a drop in performance in the year after the outbreak (i.e. 2002), with some indication that the effect of the outbreak persisted into following years. These estimates for later years are however smaller and not statistically significant and suggests that those who were younger during the outbreak were either less affected or managed to catch up in their learning by the time they took the age 11 tests. That the effect is most apparent for the cohort that took the tests in 2002 is consistent with evidence that pupils make the most learning gains between the ages of 9 and 11 in English primary schools (Gray et al, 2004) and therefore would be most affected by school disruption. The overall fall in performance appears to be driven by the effects on maths performance. A potential reason for this is that attainment in mathematics may be more reliant on pre-requisite knowledge obtained in earlier schooling compared to English and science, which means that the effect of learning loss will be more persistent and that pupils are less likely to catch up. A puzzling result is the lack of any effect detected in the year of the outbreak (2001). This may be because the 2001 tests occurred near the beginning of the outbreak and thus the disruption to learning was limited. It may also be because pupils that were particularly affected did not take the tests – something that cannot be tested with the data at hand.

4.2 Policy implications

There are two tentative policy implications from this work in terms of the current Covid-19 crisis. The first is that pupil attainment is likely to be affected by the school lockdowns, particularly in mathematics, and as such remedial provision will be required to make up for lost learning. This effect however may fade out over time and therefore remedial interventions should be carefully targeted and evaluated rather than as a blanket response to missed schooling. The results suggest that pupils who are taking high stakes assessment in the next future should be prioritized for support. The second policy implication is that school accountability measures will be affected by the Covid-19 crisis even when schools return to normal and these results provide some support for

the argument that test-based accountability requirements may need to be relaxed next year to recognize the disruptive effect of the crisis.

4.3 Limitations and further work

The main limitations of these results are twofold. The first is that the analysis is based on publicly available school level data. This means that the analysis is limited in terms of choice of research design, control variables and tests for heterogeneity of effects between different types of pupils and schools. The restriction of the sample to schools with more than ten pupils in their test-taking cohort means that small schools (mainly in rural areas) are not included in this analysis. Given their rurality, it is potentially these schools that were most affected by the FMD outbreak and so the effects of the outbreak may be underestimated. On the other hand, the results may overestimate the effect of the outbreak if it induced differential effects on pupil migration such that higher attaining pupils were more likely to leave affected schools after the outbreak. The second limitation is that the treatment variable, the indicator of whether a school was significantly affected by FMD, was a subjective designation by local government and provides little information as to the nature and intensity of the disruption for each individual school. Future research could usefully exploit pupil level datasets[9] to solve these issues. This may include the matching of pupil level records to infected farm addresses to get a clearer idea of the effect of the outbreak on affected families.

[9] The access to such datasets is currently challenging due to temporary closure of research facilities that allow access to this data.

5 References

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